EVOLUTION OF THE RELATIONSHIP BETWEEN
WEATHER FORECASTERS AND NUMERICAL MODELS
OVER THE LAST 50 YEARS

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The first numerical forecasts in the 1950s were viewed by many weather forecasters as competition and a threat to their livelihoods. In relatively short order, however, the forecasters realized the models provided excellent guidance, enabling the forecasters to improve the accuracy of their predictions.

The first computer-based forecasts run on an operational schedule at the Joint Numerical Weather Prediction Unit in 1955 proved of little use to weather forecasters. In 1958 the numerical forecasts improved to the point they became beneficial to forecasters in their daily operations. By 1960 the numerical forecasts of some fields, such as 500-mb heights, were so skillful they supplanted the human forecasts.

Now in 2004 more than 99% of NCEP's analysis and forecast products are prepared without human intervention. That remaining 1%, however, has significant impact on the accuracy and usefulness of the numerical products. The improvements over the years resulted in large part from the close working relationship between the model developers and the forecasters who used the models on a daily basis, becoming familiar with their strengths, weaknesses, and biases, so they could provide critical evaluation of the models and proposed model enhancements (Shuman, 1989).

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The skill of weather forecasts is now at a level only dreamed of by those early forecasters. Not only is the improvement significant in the accuracy of the prediction of the day-to-day weather, but just as important has been the increase in the skill in forecasting extreme events. Despite the progress, there is considerable room for improvement. For example, the Hydrometeorological Prediction Center's (HPC's) threat score for prediction of one inch or more of precipitation in the first 24-hour period, when calculated over the U.S. for a year, was 0.29 in 2003. See Fig. 1.

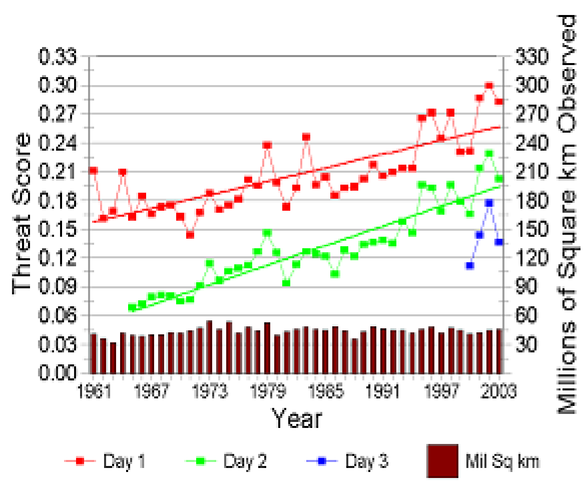

Figure 1. HPC QPF verification. 1-inch threat score for forecast days 1, 2, and 3.

(The threat score ranges from zero for a forecast with no skill to 1.00 for a perfect forecast.) This was HPC's third-best performance since record keeping began in 1961, bested only by 2001 and 2002. HPC's skill in 2003 represents about an 18% improvement over NCEP's numerical model forecasts (Fig. 2). The average annual skill improvement in QPF is about 1.6% for models and forecasters (Reynolds, 2003).

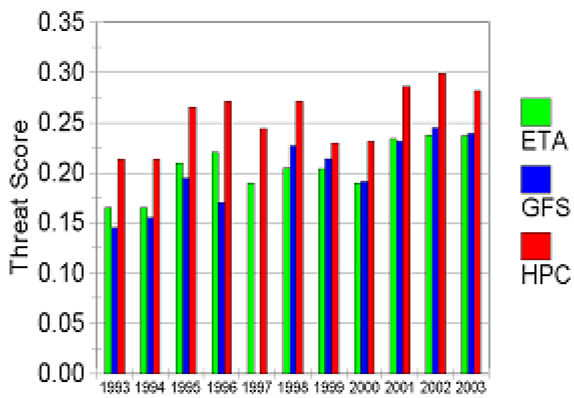

Figure 2. HPC QPF verification vs. the Eta Model and the Global Forecast System (GFS). 1-inch threat score for day 1.

Widespread convection influenced heavily by mesoscale variations in the land, water, and atmosphere makes warm season forecasting especially problematic, as indicated by much lower skill in May through August (Fig. 3).

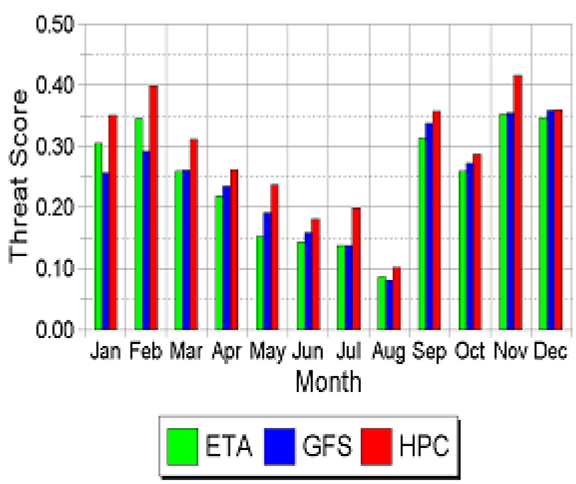

Figure 3. HPC QPF verification. 1-inch threat score for day 1, Jan-Dec 2003.

Despite the science moving toward the theoretical predictability limits, forecasters continue to add value to the forecasts, although how they do this is evolving. The successful forecasters of the medium range (days 3-7) have learned to pick their battles. For example, they confine their changes to the model forecasts to those situations and localities where they feel they can outperform the models. Fig. 4 shows the month-by-month improvement for days 3-7 over the Model Output Statistics (MOS) based on the Global Forecast System (GFS) in 2003 for maximum temperature. With few exceptions the forecasters added value to the MOS forecasts. Note the forecasters on the average changed the forecasts at about 25% of the MOS points across the U.S.

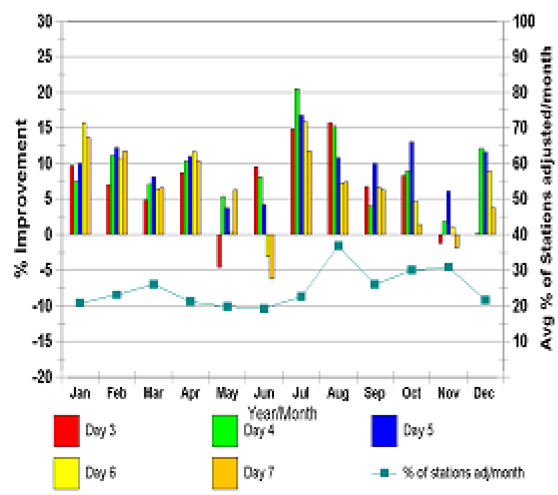

Figure 4. HPC medium-range maximum temperature verification. Percent reduction in Mean Absolute Error over MOS (2003 – adjusted stations only).

When viewed over the last four years, medium-range forecasters are reducing the error in the MOS forecasts of maximum temperature by 5% or more (Fig. 5). In general, the value added by the forecasters does not necessarily decrease with time into the forecast period from 4 through 7 days.

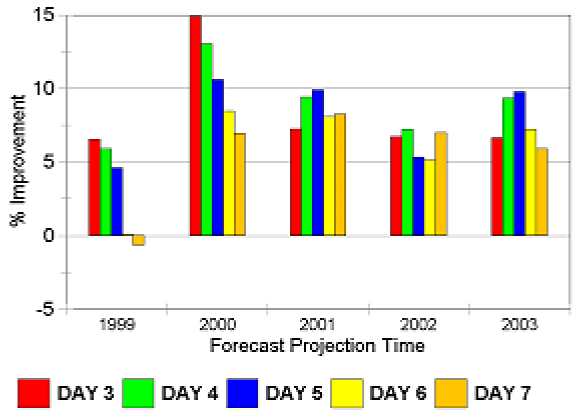

Figure 5. HPC medium-range maximum temperature verification. Percent reduction in Mean Absolute Error over MOS (by year – adjusted stations only).

Numerical ensemble prediction offers one of the newest challenges and opportunities for weather forecasters. Ensemble prediction has considerably altered the forecast process at the HPC in preparing deterministic forecasts four to seven days into the future and is used operationally in its probabilistic 1-2-day winter weather predictions. Work is underway to further the use of ensembles in probabilistic prediction at the HPC. Model ensembles have transitioned from being a novelty whose usefulness was difficult to predict to being an essential part of the medium-range forecast process. The model ensembles provide the forecasters with a spectrum of possible outcomes, a rationale for selecting the most likely outcomes, and a indication of the uncertainty/confidence in the forecasts.

In conclusion, weather forecasters have been extremely adaptive. As the technology and science have enhanced such tools as numerical prediction models and sophisticated meteorological workstations, forecasters have adopted methods by which they continue to add value to the forecast process. This value takes the form of more accurate weather predictions as the forecasters apply their understanding of model biases in general and in various weather regimes in association with solutions offered by myriad ensemble members, serve as advisors to customers by tailoring products and services to their specific needs, and provide a human sanity check and oversight of a highly automated weather prediction system. Additionally forecasters provide a major service to the numerical model developers by providing feedback on model strengths and weaknesses, as well as evaluations of the performance of proposed model changes. The results are numerical weather forecasts of continually increasing accuracy.

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